

Usable storage in impounding reservoirs is maintained in both watershed areas. The Cedar River shed maintains 40,000 acre ft and the Tolt River reservoir maintains 58,000 acre ft. At present, the transmission capacity from the Cedar River area amounts to 240 MGD and the lines from the Tolt River area have a capacity of 100 MGD, providing a total delivery capability of 340 MGD.

TREATMENT

The Seattle Water Department has no specific treatment facility as such and depends heavily on controlling the quality of the source water,

Copper sulfate is added at some of the reservoirs and regulating basins and sodium thiosulphate is added for dechlorination purposes. Sodium hypochlorite is used to disinfect new mains and calcium hypochlorite is used to maintain quality control.

Chlorine and fluoride are added to the water as it leaves the watershed areas and additional chlorine is added at 13 points in the supply system as water is delivered to retail customers. Water delivered to wholesale customers is chlorinated only at the watershed area. Figure 79 shows the points where chlorine and fluoride are added.

TRANSMISSION AND DISTRIBUTION

The transmission and distribution system consists of approximately 1,547 miles of pipe most of which is underground. The general topography of the retail service area is between 0 and 500 ft in elevation. Only small portions of the direct service lie in areas over 500 ft in elevation. There are three levels of pressure zones, generally referred to as low (up to 200 ft), intermediate (200 to 350 ft), and high (350 to 500 ft). Generally, the low and intermediate zones are supplied by gravity and the high service zones are supplied by pumping.

Table 144 shows the capacity and elevation of the system's storage facilities. The storage capability in the distribution system consists of 12 reservoirs, nine standpipes, and eight tanks, providing a total storage of over 445 mil gal. Most of this is in reservoirs. Even during maximum consumption periods, the water system maintains storage at about 84% of total capacity.

COST ANALYSIS

Growth in consumer demand for water from 1965 to 1974 is illustrated in Figure 80. Demand for water increased through 1967 and remained relatively stable from that point on.

Using the standard cost categories, data were collected and reported as shown in Tables 145, 146, and 147. Since a major portion of the operating budget was expended for labor, Table 148 was developed to examine labor costs of the operations and maintenance of the department. The cost/man-hour

Figure 79. Seattle Water Department location of system treatment facilities.

TABLE 144. SEATTLE WATER DEPARTMENT STORAGE FACILITIES

Facility	Capacity (mil gal)	Overflow elevation (ft)
Reservoirs:		
Beacon Hill North	61	316
Beacon Hill South	49	316
Bow Lake	6	458
Green Lake	50	316
Lincoln	21	316
Magnolia Manor	5.5	320
Maple Leaf	58.5	420
Volunteer Park	20	420
S.W. Myrtle St.	7	488
West Seattle	68	430
Bitter Lake	21.5	499
Lake Forest	60	540
Standpipes:		
S.W. Barton St.	1.4	316
S.W. Charleston St.	1	488
Foy	1	580
Queen Anne	0.3	520
Queen Ann	0.9	520
S.W. Trenton St.	1.2	320
S.W. Trenton St.	1.2	320
Volunteer Park	0.9	520
Woodland Park	1	420
Tanks:		
Beverly Park	2	575
S. Leo St.	0.5	372
Magnolia Bluff	1	470
Maple Leaf	1	520
Richmond Highlands	1	580
Richmond Highlands	2	580
S.W. Myrtle St.	0.5	575
S.W. Myrtle St.	1	575

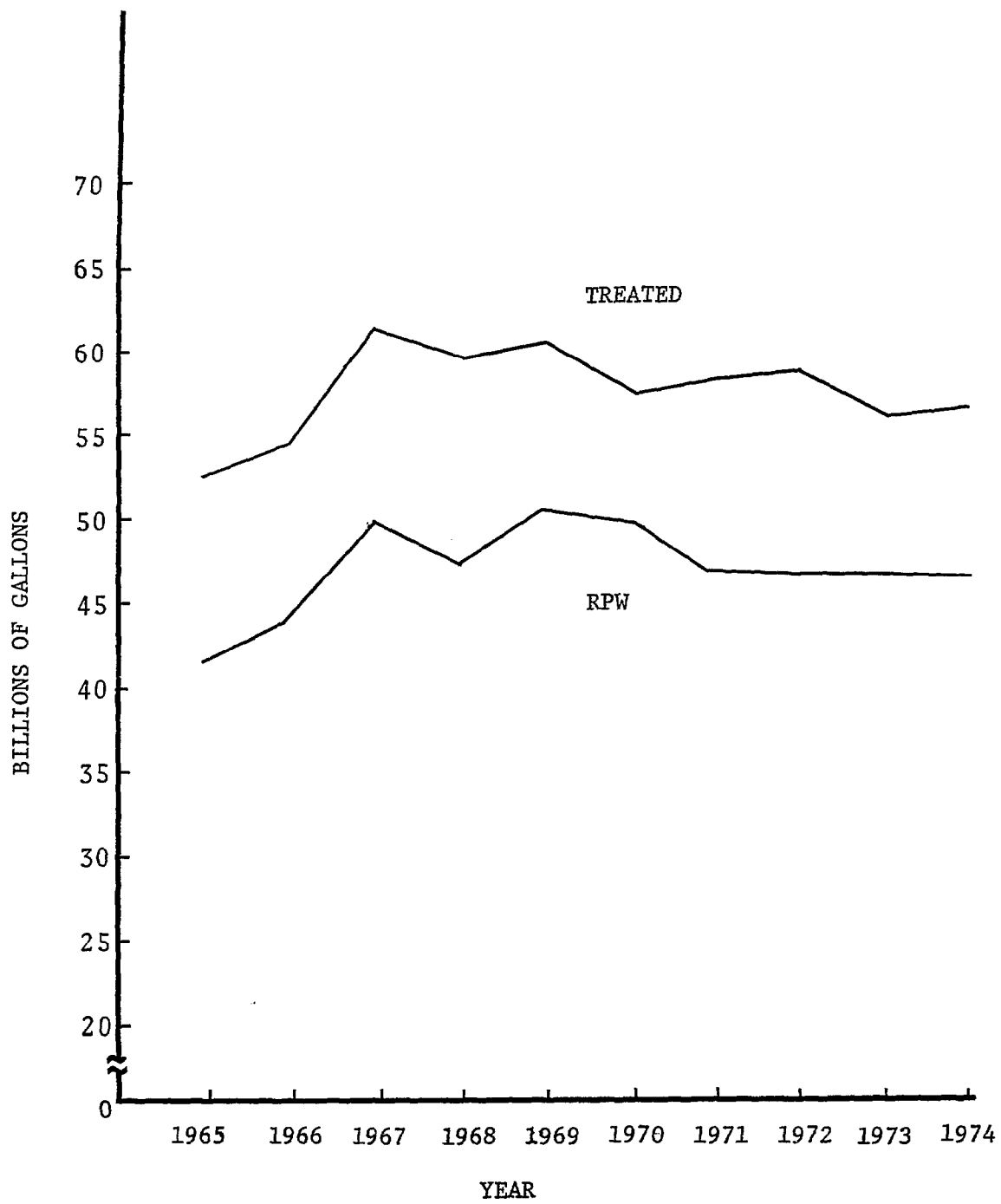


Figure 80. Seattle Water Department water flow:
treated water versus RPW.

TABLE 145. SEATTLE WATER DEPARTMENT ANNUAL OPERATING COSTS

Category	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Support services:										
Administration	\$243,940	\$242,601	\$227,889	\$248,669	\$258,719	\$255,808	\$283,293	\$295,206	\$348,973	\$490,454
Employee pension and benefits	*	*	507,533	561,000	685,341	971,523	1,108,134	1,236,080	1,438,805	1,442,510
Commercial	553,068	544,748	424,285	455,084	473,273	471,345	506,786	568,360	536,445	608,736
Taxes	1,011,909	1,089,770	1,232,892	1,288,440	1,375,555	1,438,671	1,680,017	1,724,002	1,779,936	1,793,864
Miscellaneous undistributed	205,071	202,719	228,383	268,487	275,932	284,768	291,126	335,402	395,690	407,839
Other	49,802	52,122	49,360	55,604	112,823	(67,944)	(17,496)	(15,635)	78,631	67,031
Total support services	2,063,790	2,131,960	2,670,342	2,877,284	3,181,643	3,354,171	3,851,860	4,143,415	4,578,480	4,810,434
Acquisition:										
Acquisition	310,471	319,427	295,447	328,272	465,523	392,376	449,227	455,251	448,903	491,373
Transmission	325,624	283,601	263,828	308,527	275,704	306,710	347,777	402,438	382,544	442,319
Total acquisition	636,095	603,028	559,275	636,799	741,227	699,086	797,004	857,689	831,447	933,692
Treatment:	227,966	266,233	258,862	263,627	329,040	495,615	529,730	539,280	582,333	584,998
Power and pumping:										
Pumping	131,111	121,825	98,145	103,511	123,330	107,125	104,167	132,923	140,004	173,236
Other	27,695	29,551	22,769	23,188	30,521	26,453	25,558	24,004	23,934	21,962
Total power and pumping	158,806	151,375	120,914	126,699	153,851	133,478	129,725	156,927	163,938	195,198
Transmission and distribution:										
Superintendence	121,762	142,630	130,791	156,926	173,144	206,270	206,014	216,770	267,091	488,042
Mains, hydrants, and fountains	388,954	310,777	349,321	386,710	435,888	448,450	537,644	598,318	593,301	572,097
Services	292,325	282,849	263,765	330,491	312,957	400,242	410,595	559,131	524,806	424,704
Meters	200,505	205,005	179,207	207,285	212,954	234,209	257,459	294,110	311,654	304,097
Other	276,089	310,901	285,710	318,888	383,268	431,397	467,297	372,953	354,836	262,906
Total transmission and distr.	1,279,635	1,252,162	1,208,794	1,400,300	1,518,211	1,720,568	1,879,009	2,041,282	2,051,688	2,051,846
Total operating cost	4,366,292	4,404,758	4,818,187	5,304,709	5,923,972	6,403,018	7,187,328	7,738,593	8,207,886	8,576,168

* Distributed to operating expense accounts.

TABLE 146. SEATTLE WATER DEPARTMENT UNIT OPERATING COSTS (\$/mil gal RPW)

Category	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Support services:										
Administration	\$6.01	\$5.68	\$4.67	\$5.34	\$5.16	\$5.15	\$6.10	\$6.40	\$7.61	\$10.68
Employee pension and benefits	*	*	10.41	12.04	13.66	19.55	23.87	26.81	31.38	31.42
Commercial	13.62	12.75	8.70	9.77	9.43	9.48	10.92	12.33	11.70	13.26
Taxes	24.91	25.50	25.29	27.66	27.42	28.94	36.18	37.40	38.82	39.08
Misceallaneous undistributed	5.05	4.74	4.68	5.76	5.50	5.73	6.27	7.28	8.63	8.88
Other	1.23	1.22	1.01	1.19	2.25	-1.37	-0.38	-0.34	1.71	1.46
Total support services	50.81	49.89	54.77	61.77	63.42	67.48	82.96	89.88	99.86	104.79
Acquisition:										
Acquisition	7.64	7.48	6.06	7.05	9.28	7.89	9.68	9.88	9.79	10.70
Transmission	8.02	6.64	5.41	6.62	5.50	6.17	7.49	8.73	8.34	9.64
Total acquisition	15.66	14.11	11.47	13.67	14.77	14.06	17.17	18.61	18.13	20.34
Treatment:	5.61	6.23	5.31	5.66	6.56	9.97	11.41	11.70	12.70	12.74
Power and pumping:										
Pumping	3.23	2.85	2.01	2.22	2.46	2.16	2.24	2.88	3.05	3.77
Other	0.68	0.69	0.47	0.50	0.61	0.53	0.55	0.54	0.52	0.48
Total power and pumping	3.91	3.54	2.48	2.72	3.07	2.69	2.79	3.40	3.58	4.25
Transmission and distribution:										
Superintendence	3.00	3.34	2.68	3.37	3.45	4.15	4.44	4.70	5.83	10.63
Mains, hydrants, and fountains	9.58	7.27	7.16	8.30	8.69	9.02	11.58	12.98	12.94	12.46
Services	7.20	6.62	5.41	7.10	6.24	8.05	8.84	12.13	11.45	9.25
Meters	4.94	4.80	3.68	4.45	4.24	4.71	5.55	6.38	6.80	6.62
Other	6.80	7.28	5.86	6.85	7.64	8.68	10.06	8.09	7.74	5.73
Total transmission and distr	31.50	29.30	24.79	30.06	30.26	34.61	40.47	44.28	44.75	44.70
Total operating cost	107.50	103.08	98.82	113.89	118.08	128.82	154.80	167.87	179.02	186.82

* Distributed to operating expense accounts.

The above figures are not additive. They are obtained by dividing yearly mil gal RPW into the annual costs shown in the preceding table.

TABLE 147. SEATTLE WATER DEPARTMENT OPERATING COST CATEGORIES AS PERCENT OF TOTAL OPERATING COST

Category	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Support services:										
Administration	5.59	5.51	4.73	4.68	4.37	4.00	3.94	3.81	4.25	5.72
Employee pension and benefits	*	*	10.53	10.57	11.57	15.18	15.42	15.97	17.53	16.82
Commercial	12.67	12.37	8.81	8.57	7.99	7.36	7.05	7.34	6.54	7.10
Taxes	23.16	24.74	25.59	24.30	23.22	22.46	23.35	22.29	21.67	20.92
Miscellaneous undistributed	4.70	4.60	4.74	5.06	4.66	4.45	4.05	4.33	4.82	4.75
Other	1.14	1.18	1.02	1.05	1.90	-1.06	-0.24	-0.20	0.96	0.78
Total support services	47.26	48.40	55.42	54.23	53.71	52.39	53.57	53.54	55.77	56.09
Acquisition:										
Acquisition	7.11	7.25	6.13	6.19	7.86	6.13	6.25	5.88	5.47	5.73
Transmission	7.46	6.44	5.48	5.82	4.65	4.79	4.84	5.20	4.66	5.16
Total acquisition	14.57	13.69	11.61	12.01	12.51	10.92	11.09	11.08	10.13	10.89
Treatment:	5.22	6.04	5.37	4.97	5.55	7.74	7.37	6.97	7.09	6.82
Power and pumping:										
Pumping	3.01	2.77	2.04	1.95	2.08	1.67	1.47	1.72	1.71	2.02
Other	0.63	0.67	0.47	0.44	0.52	0.41	0.36	0.31	0.29	0.26
Total power and pumping	3.64	3.44	2.51	2.39	2.60	2.08	1.83	2.03	2.00	2.28
Transmission and distribution:										
Superintendence	2.79	3.24	2.71	2.96	2.92	3.22	2.87	2.80	3.26	5.69
Mains, hydrants, and fountains	8.91	7.06	7.26	7.29	7.37	7.01	7.47	7.73	7.24	6.67
Services	6.70	6.42	5.47	6.23	5.28	6.25	5.71	7.23	6.39	4.95
Meters	4.59	4.65	3.72	3.91	3.59	3.65	3.58	3.80	3.80	3.55
Other	6.32	7.06	5.93	6.01	6.47	6.74	6.51	4.82	4.32	3.06
Total transmission and distr	29.31	28.43	25.09	26.40	25.63	26.87	26.14	26.38	25.01	23.92
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE 148. SEATTLE WATER DEPARTMENT LABOR COST ANALYSIS

Item	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Total payroll (\$)	2,755,495	2,815,573	3,168,326	3,590,589*	4,012,852	4,404,520	4,675,882	4,931,418	5,178,590	5,298,896
Total hours on payroll*	883,353	861,621	899,788	1,018,178	980,137	1,014,563	1,016,644	1,033,079	1,002,604	906,261
Revenue-producing water (mil gal)	40,618	42,731	48,759	46,578	50,169	49,706	46,429	46,099	45,849	45,967
Total payroll/mil gal RPW (\$)	67.84	65.89	64.98	77.09	79.99	88.61	100.71	106.97	112.95	115.28
Total hours/mil gal RPW	21.75	20.16	18.45	21.86	19.54	20.41	21.90	22.41	21.87	19.72
Average cost/man-hour (\$)	3.12	3.27	3.52	3.53	4.09	4.34	4.60	4.77	5.17	5.85

increased over the 10 years by 88% and the total payroll, hours required to produce 1 mil gal RPW decreased by approximately 9%. Thus the operating costs for producing water did not increase as rapidly as the labor cost/man-hour. However, when it is no longer possible to gain increased efficiencies with respect to manpower, the payroll cost will increase at least at the same rate as the labor cost.

Table 149 summarizes the operating, depreciation, and interest expenses for the 10-year period of analysis. Table 150 computes capital and operating expenditure ratios. The operating expenses in these tables are those shown as totals of the values in Table 145, expenses incurred in the normal day-to-day operation of the system. Capital expenses are the total expenses for providing major equipment and facilities plus the interest charged on money borrowed for those purposes.

A comparison of operating and capital expenses as a percent of total cost shows that in the Seattle Water Department, greater expense is incurred in operations than in capital outlay. This trend continued over the 10-year period primarily as a result of continued increases in the cost of items necessary to operations, such as increasing salaries. No capital expenditures were made during this period and the ratio of capital to operating expense shifted from 62% operating versus 38% capital to 71% operating versus 29% capital.

The Seattle Water Department's system is relatively old; therefore, the capital depreciated was expended when costs were significantly lower than at present. On the other hand, the operating expense is in current dollars. This ratio will increase as capital investments are made by the utility. For example, major capital expense may be required in the future to expand the source of water supply or additional treatment facilities may be needed to meet the requirements of the Safe Drinking Water Act. Should either of these eventualities occur, the ratio of capital to operating expense will increase significantly.

SYSTEM COSTS

Examination of costs on a functional basis is only a part of the total picture. Because the purpose of a water supply utility is to deliver water to the customers, it is important to be able to present costs as they relate water delivery to a demand point in the distribution system. For this reason, the functional categories, both operating and capital, are reaggregated and assigned to physical components in the water delivery system. This section contains such an analysis.

Locations of the service area and the watersheds in the mountains to the east of the service area are shown in Figure 81. Because the watersheds provide water primarily by gravity to the northern extremity of the distribution system and on toward the middle of the service area, there is little incremental cost for providing water to the distribution system other than the differences in the cost of the sources and in moving the water from the source to the distribution system.

TABLE 149. SEATTLE WATER DEPARTMENT CAPITAL AND OPERATING COSTS

Item	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Operating expense	\$4,366,292	\$4,404,758	\$4,818,187	\$5,304,709	\$5,923,972	\$6,403,018	\$7,187,328	\$7,738,593	\$8,207,886	\$8,576,168
Depreciation	1,761,320	1,819,344	1,858,194	1,883,228	1,924,747	1,995,275	2,064,071	2,122,696	2,236,003	2,285,054
Interest	954,300	942,601	927,385	977,691	1,082,324	1,051,397	1,046,567	1,187,107	1,266,572	1,234,900
Total	7,082,412	7,166,703	7,603,166	8,165,628	8,931,043	9,449,690	10,297,966	11,048,396	11,709,466	12,096,122
Total cost/mil gal RPW	174.37	167.71	155.95	175.31	178.02	190.11	221.80	239.67	255.39	263.15

TABLE 150. SEATTLE WATER DEPARTMENT CAPITAL VERSUS OPERATING EXPENSE RATIOS

Item	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Operating expense (\$)	4,366,292	4,404,758	4,818,187	5,304,709	5,923,972	6,403,018	7,187,328	7,738,593	8,207,886	8,576,168
Capital expense (\$)	2,716,120	2,761,945	2,784,979	2,860,919	3,007,071	3,046,672	3,110,638	3,309,803	3,501,580	3,519,954
Total (\$)	7,082,412	7,166,703	7,603,166	8,165,628	8,931,043	9,449,690	10,297,966	11,048,396	11,709,466	12,096,122
Operating expense as % of total	61.65	61.46	63.37	64.96	66.33	67.76	69.79	70.04	70.10	70.90
Capital expense as % of total	38.35	38.54	36.63	35.04	33.67	32.24	30.21	29.96	29.90	29.10

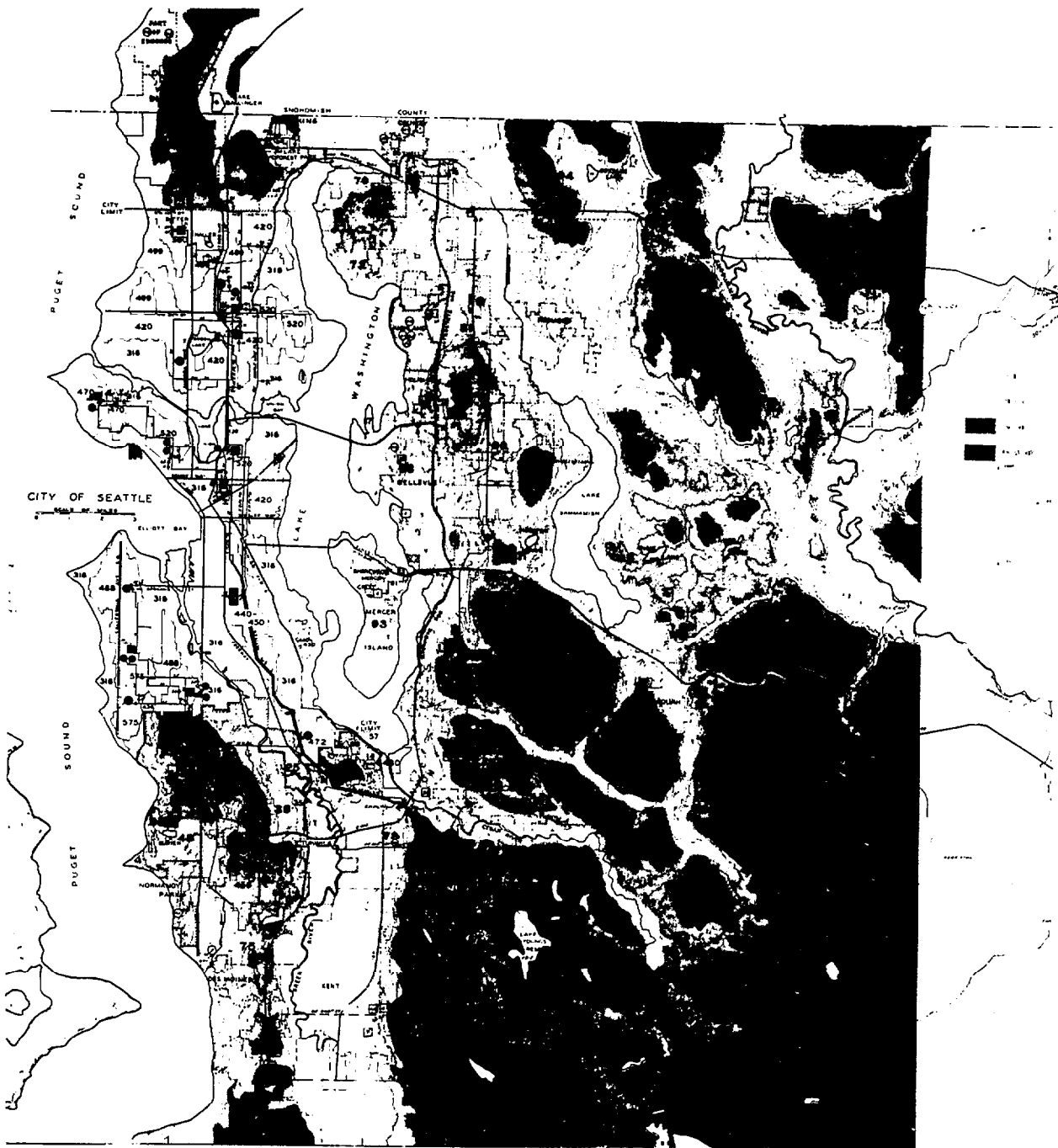


Figure 81. Seattle Water Department distribution area.

Figure 82 shows the allocation of operating and capital costs to the various components of the Seattle system. Because the major cost variation is based on the specific source of the water, the cost of the delivered water is associated with the source rather than any specific point or pressure zone of delivery to the customer.

To analyze the cost impact of the two sources, the total operating and capital cost for each of the components is identified and established in \$/mil gal of RPW. A linear assumption is made to allow cost/mil gal to be added as water moves from one component of the system to another. For example, the acquisition cost at the Cedar River watershed is \$3.78/mil gal. An additional \$29.87/mil gal is added to transmit the water from the source to the distribution system. A treatment cost of \$4.50/mil gal is incurred with the insertion of chlorine and fluoride into the water near the source, and another \$5.70/mil gal is incurred in adding chlorine and other chemicals in the distribution system. An additional average cost of \$5.06/mil gal is incurred in pumping the water. The total incremental cost is thus \$48.91/mil gal for providing water from the Cedar River watershed (Table 151). Added to these incremental costs are the distribution, interest, and support services costs. Calculation of the distribution cost is based on the assumption that these unit costs (\$/mil gal) are constant throughout the system; therefore, the total capital and operating cost for distribution is divided by the number of gallons of RPW in the year under consideration, yielding a figure of \$72.16/mil gal. The same approach is used to calculate interest and support services costs. When these are added, the total cost of water from the Cedar River source is \$257.05/mil gal.

Tables 152, 153, and 154 summarize typical monthly water rates charged by the Seattle Water Department.

Table 155 shows the cost of water delivered to the 10 largest customers of the department. Comparing each user's location with the cost allocation table makes it possible to identify the actual allocated cost of delivering water to a specific customer. Locations of major users are shown in Figure 83. Most of them are in the central or southern portion of the service area, predominantly supplied by the Cedar River watershed.

The average unit costs for all water supplied during the most recent year studied are given as follows:

	<u>\$/mil gal</u>
Support Services-----	109
Acquisition-----	37
Treatment-----	13
Distribution-----	77
Interest-----	27
Total-----	263

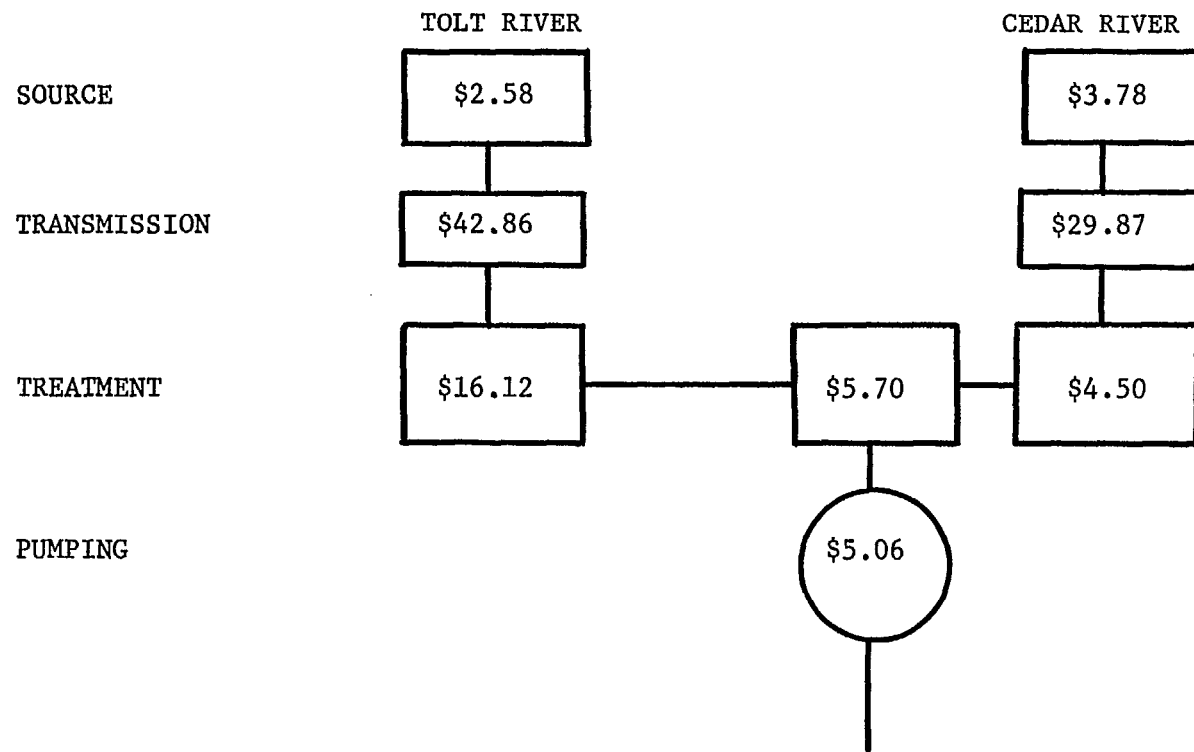


Figure 82. Seattle Water Utility allocation of capital and operating expenses to system components (\$/mil gal RPW).

TABLE 151. SEATTLE WATER UTILITY COST ELEMENTS BY SOURCE

Water Source	Incremental cost (\$/mil gal)	Distribution cost (\$/mil gal)	Interest (\$/mil gal)	General Services (\$/mil gal)	Total unit cost (\$/mil gal)	RPW (mil gal)	Revenue
Tolt River	72.32	72.16	26.86	109.12	280.46	11,967	3,356,265
Cedar River	48.91	72.16	26.86	109.12	257.05	34,000	8,739,700
Total	---	---	---	---	---	45,967	12,095,965

TABLE 152. SEATTLE WATER DEPARTMENT MINIMUM CHARGE BY METER SIZE
INSIDE CITY LIMITS

Meter size (in.)	Monthly volume base (cu ft)	Minimum charge
3/4	300	\$ 2.10
1	600	2.80
1½	1,200	4.10
2	2,000	5.80
3	3,400	8.70
4	4,900	12.00
6	7,100	16.50
8	10,000	23.00
10	14,000	31.50
12	20,000	44.00

TABLE 153. SEATTLE WATER DEPARTMENT MINIMUM CHARGE BY METER SIZE
OUTSIDE CITY LIMITS*

Meter Size (in.)	Monthly volume base (cu ft)	Minimum charge
3/4	300	\$ 3.15
1	600	4.20
1½	1,200	6.15
2	2,000	8.70
3	3,400	13.05
4	4,900	18.00
6	7,100	24.75
8	10,000	34.50
10	14,000	47.25
12	20,000	66.00

* Other than water districts or cities.

TABLE 154. SEATTLE WATER RATES FOR ALL METER SIZES

Use level	Rate
Inside city limits:	
Each 100 cu ft over your volume base, to 30,000 cu ft	\$0.213
Each 100 cu ft after 30,000 cu ft	.142
Each separate building or premises supplied through the same connection (except trailer parks), minimum charge for 500 cu ft, volume base	2.50
Outside city limits:	
Each 100 cu ft over your volume base, to 30,000 cu ft	.32
Each 100 cu ft after 30,000	.213
Each separate building or premises supplied through the same connection (except trailer parks), minimum charge for 500 cu ft, volume base	3.75

TABLE 155. SEATTLE WATER DEPARTMENT WATER COSTS FOR 10 MAJOR USERS

Major users	High or low month	Month	Units used (mil gal)	Amount billed	Unit charge (\$/mil gal)	Cost zone
Boeing	High	10	121.3	\$19,606	\$161.64	2
	Low	12	89.6	14,260	159.16	
University of Washington	High	11	64.5	8,702	134.93	1
	Low	2	42.5	5,768	135.56	
Port of Seattle	High	2	53.1	7,396	139.29	2
	Low	5	36.8	5,135	139.64	
Bethlehem	High	6	38.8	5,231	134.92	2
	Low	12	26.2	3,547	135.51	
Todd Shipyards	High	7	34.6	4,660	134.61	2
	Low	1	15.9	2,368	148.65	
Sicks Ranier	High	7	32.0	4,349	135.71	2
	Low	2	15.9	2,193	137.78	
Northwestern Glass	High	8	21.1	2,868	135.94	2
	Low	5	14.2	1,947	137.09	
E.M. Jorgensen	High	2	28.0	5,684	203.23	2
	Low	4	3.9	852	220.00	
Seattle Steam Corporation	High	1	26.2	1,466	55.90	2
	Low	9	7.1	981	138.29	
Monsanto	High	10	22.7	4,610	201.63	2
	Low	5	9.9	2,010	203.20	

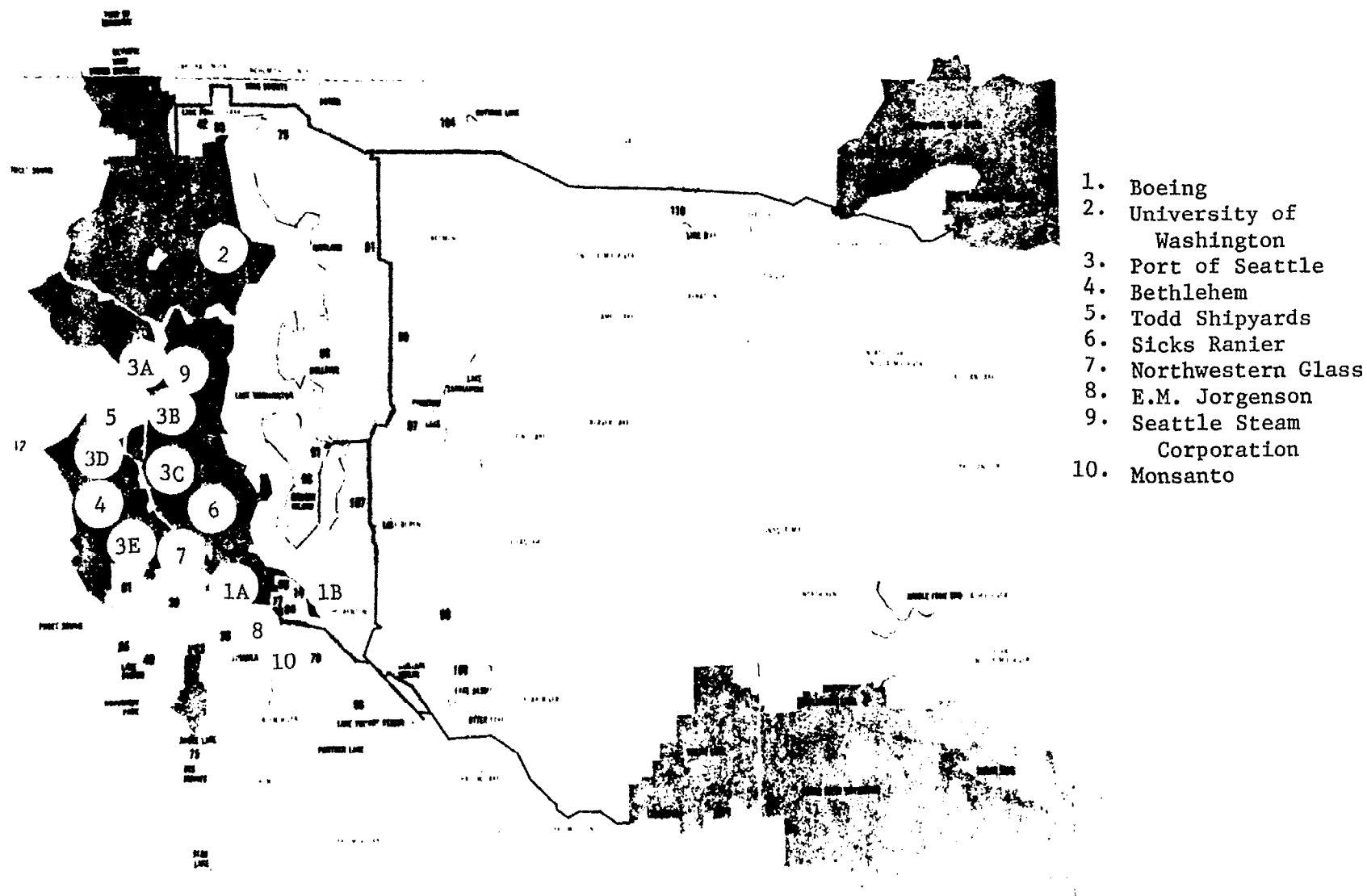


Figure 83. Locations of Seattle Water Department major users.

TECHNICAL REPORT DATA <i>(Please read Instructions on the reverse before completing)</i>		
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16. ABSTRACT A study of 12 selected water utilities was undertaken to determine the economics of water delivery. Data were collected from at least one Class A water utility (revenues greater than \$500,000/year) in each of the U.S. Environmental Protection Agency's 10 regions. These data are summarized in two volumes. Volume II contains the basic data from each of the 12 utilities studied. Services of each utility were divided into five functional areas common to all water supply delivery systems - support services, acquisition, treatment or purification, distribution and power and pumping. These categories provided a common basis for collecting and comparing data. Costs were categorized as operating or capital expenditures.		
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